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La magie utilisée pour enseigner les éléments-clé en sciences

Using Magic to teach key items in Science

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RÉSUMÉ — SUMMARY

Science is intrinsically fun for science-oriented, science-minded students. However, for most people Science has two main issues: its language (mathematics) and abstract or complex items, like entropy or DNA bases. Our team is gathering a collection of short magic games to better teach those concepts and make Science more attractive and understandable. For instance, we use playing cards to explain the basics of quantum mechanics (Schröndinger's Card). We use the four card suits and their red/black characteristic to deal with DNA pair bonding. Another example concerns entropy, both as a physicochemical concept, and an information theory item. This communication pinpoints several examples of the use of conjuring techniques to foster Science learning and making it relevant and attractive enough for students. These games can be related to current mid- and hight school curricula; they are also used in the MOOC "Magic, Science and Confessable Secrets" which is currently under development.

PRÉSENTATION DÉTAILLÉE — DETAILED PRESENTATION

Introduction

There is a wealth of connections between magic and science: psychology, neuroscience, mathematics, physics or chemistry (among others) allow to rationalize such connections. Furthermore, as Alex Stone states in his book "Fooling Houdini", [1] the world of Magic is filled with scientists and the world of Science is filled with magicians; moreover, Scientists and Magicians are both people who take an interest in mysteries. Science is intrinsically fun for science-oriented, science-minded students. They make fun of it, they enjoy it, they contribute to expand it. However, for most people, Science has two main difficult issues: its language (mathematics) and abstract or complex items. Here Magic comes to rescue: it may help non-science-

oriented students and citizens to better connect with Science.

All in all, one may think of various levels of Public relationship with Science: one may think of Public Awareness of Science (PAS), but also of Public Engagement with Science (PES), which is more involved. Moreover, one may think of Public Understanding of Science (PUS) and indeed finally Science Education. Note that one may substitute "Science" with "STEM" (Science, Technology, Engineering and Mathematics" and even "STEAM" (including Arts).

Our team is currently involved in a project entitled "From the Magic of Science to the Science of Magic" (#magsci), funded by Spain's FECyT [2]. It tackles the aforementioned four stages of Public relationship with Science (PAS, PES, PUS and Science Education). It six main tasks, developed along with undergraduate and graduate Science students, are:

• Stage show, The Mathemagic of Science, pinpointing the connections between general scientific facts and illusionism, mainly using mathematical magic (#lammc)

• Stage show, The Magic of the Periodic Table, showcasing specific magic involving the Periodic Table of the Elements (Honours Mention at Ciencia en Acción, Barcelona, 2014) (#lamtp)

• I Meeting on Science, Magic and Education, 3-day event held at Girona on April 2014 [3] (#ecme15)

• MOOC on Magic and Science, to be delivered in Autumn 2015 [4] (#magcimooc)

• Participative activities at schools and at Unviersity facilities.

• Mobile apps on magic and science, gamification of recreational science.

The stage show "The Magic of the Periodic Table" has been presented in quite a few Spanish cities, among them Barcelona, Zaragoza, Sevilla, Valladolid. Besides being shown for Science&You in Nancy, it will be shown in the Science on Stage festival in London, in mid-June 2015.

The I Meeting on Science, Magic and Education gathered ca. 50 magicians, educators and researchers, both from Spain and abroad, with the purpose of analyzing further the tools and purpose of using magic to foster the learning process. Along with the very meeting, this team organized a Magic&Science Itinerary through the Old City of Girona, thus joining Heritage and Naturalist Tourism with Magic, always from a scientific point of view. This Itinerary (ca. 2 hours long) is being offered, for the academic year 2015/16, to all schools in Girona as an extracurricular activity.

Last but not least, we have been organizing montly meetings at a local bar to delve into the relationship between Magic and Science (Beers, Magic & Science), thus gathering interested students and introducing them to this field.

Teaching key Science terms

Magic, when used wisely, is able to make things more attractive, and thus contribute to understanding of Science concepts. However, when considering Magic as a tool to provide a learning success of Science items, terms and concepts, one must take into account that Magic should be used cautiously: students should remember the concept, rather that the surprise the effect brings about.

Magic may make things more attractive, and this is one of its key properties. However, Magic is also able to improve the learning process by disguising the intrinsics and details of complex concepts (i.e., entropy). Of course, Magic should not be used as a standalone tool in Science; on the contrary, it should be combined with other motivational and learning tools.

A few examples on Magic and Science concepts

Random numbers: shuflling the cards, shuffling them well enough.

The binary notation: base 2 explanation - red/black card suits.

Base 4 is easy: the four playing card suits

Algotithms and information theory

Chain convergence: the Kruskaal Principle

3D geometry: Origami, Flexagons, Hypercard

Probability: The Monty Hall problem, Paradoxes, Lateral thinking

Topology: Using ropes and similar materials

Algebra: Spelling trick by Martin gardner, Divisibility, the 9-rule, 1089, 142957 numbers...

Shcrödinger's Card/Quantum Mechanics: Superposition principle, quantum computing, quantym cryptography

Einstein-Podalski-Roser entangled particle pairs: Gilbreath Principle.

Chemical Inmiscibility: Oil & Water card effects

Physical basics: Magnetism, gravity effects

Physical observables: sensory illusions - optical, acoustical, weight

Quasicrystal: Penrose tilings, De Bruijn sequences

New materials: thermochromic, wiregram, muscle wire

Entropy: thermodynamics + information theory: Rubik's Cube, card shuffling, etc - as commonplace tools

Molecules - building them with cards, paper, food items, etc.

Chemical magic: e.g., acid-base color change, invisible ink, etc.

Eggs: multiple use in chemistry of food, mechanics of rotations, proteins

DNA base pairs: A, T, C, and G base pairs in DNA are linked A-T and C-G. Playing cards have also 2 red suits and 2 black suits.

Fibonacci-related biology: from tricks to the golden ratio

Periodic Table of the Elements: special, well-suited case because of wealth of symbols, symbol-number correspondence, and size: ca. twice the number of playing cards.

Particular remarks

On Magic and the Periodic Table

One must note that the Periodic Table of the Elements (PTE) is one of few cases in Nature based on natural numbers. It allows for allows vertical, horizontal and other groups, and there is a correspondence between numbers, symbols... and letters. Thus, it allows for adaptation and amplification of classical games and tricks, e.g. parity games: trip along the PTE, binary sorting game, Latin squares, etc. Finally, PTE is in general quite well known by a general audience, so playing with it does not hinder attractiveness; on the contrary, it provides further engagement.

On the magic of food, the magic of the kitchen

Everyone loves (tasteful) food, everyone knows about nutrition and food items. Thus, the kitchen is a suitable laboratory to perform all kinds of magic by all ages. For instance, cooking a green sunny-sideup egg

or a green omelette. In general, chemistry and physics may be taught at different levels using kitchen items. This notwithstanding, the kitchen may contain also hazardous chemicals like bleach or ammonia, so care must be taken to explain in detail that chemistry (and physics) has a dual nature and may benefit our lives but also carry some danger.

On the magical characteristic of Chemistry and Electromagnetism

Indeed, Alchemy preceded Chemistry, and Electric phenomena were considered as witchcraft no long ago. Thus, Chemistry and Electromagnetism are magical in themselves and are seen as intrinsically unexplainable by most people. This makes conjuring techniques using these two scientific fields slightly more complicated: it is difficult to explain magic using real magic tools like those.

Moreover, mentalism and mind effects are useful to attract interest. However, not everyone reacts rationally to those effects, even if they are used within the context of a Science show or explanation. They should be used carefully, thus, not to create a hindering atmosphere are lead to undesired effects.

Relationship with middle- and high-school curricula

These different games, tricks and stunts can be used to introduce lessons and activities of middle- and high-school curricula. The opposite view may be also true: it should not be difficult to find an enticing magic plot to introduce and make attractive each and every lesson or learning session.

Our Group has started such a process, by paying attention to mathematics and chemistry curricula in 15- and 16-year-old students curricula. Indeed, mathematics and chemistry are two of the disciplines where attractiveness should be especially encouraged. Chemistry in particular is a basic discipline for other Sciences, yet it is seen as obscure, difficult and lacking interest by many high school students. Of course, mathematics are unwelcome by a fair part of teenagers. We think that establishing connections between teaching units and magic the learning outcomes should be much better. This will be the subject of further comunciations and research in the near future.

Final remarks using a few relevant quotes

"The most exciting phrase to hear in science, the one that heralds new discoveries, is not 'Eureka!' (I found it!) but 'That's funny ...'" (Isaasc Asimov) (also “Oh My God!, as noted by Nobel Prize S Glashow)

"Martin Gardner has turned hundreds of mathematicians into magicians and hundreds of magicians into mathematicians" (Persis Diaconis)

"Education is not a preparation for life. Education is life itself" (John Dewey)

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[3] I Encuentro de Ciencia, Magia y Educación, hashtag #ecme15, see http://magsci.eu

[4] MOOC on "Magia, Ciencia y Secretos Confesables", http://magcimooc.net